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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

MAY 1 1974

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,864,472
Government or : U.S. Government
Corporate Employee
Supplementary Corporate :
Source (if applicable)
NASA Patent Case No. : LEW-11,076-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES ☐

NO ☒

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

Bonnie L. Woerner

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Enclosure

[54] JOURNAL BEARINGS

[75] Inventors: Fredrick T. Schuller; Warren A. Moore, both of Cleveland, Ohio

[73] Assignee: The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, Washington, D.C.

[22] Filed: Mar. 27, 1972

[21] Appl. No.: 238,264

[52] U.S. Cl. 308/73

[51] Int. Cl. F16c 17/06

[58] Field of Search 308/121, 240, 85, 9, 73

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Primary Examiner—Charles J. Myhre

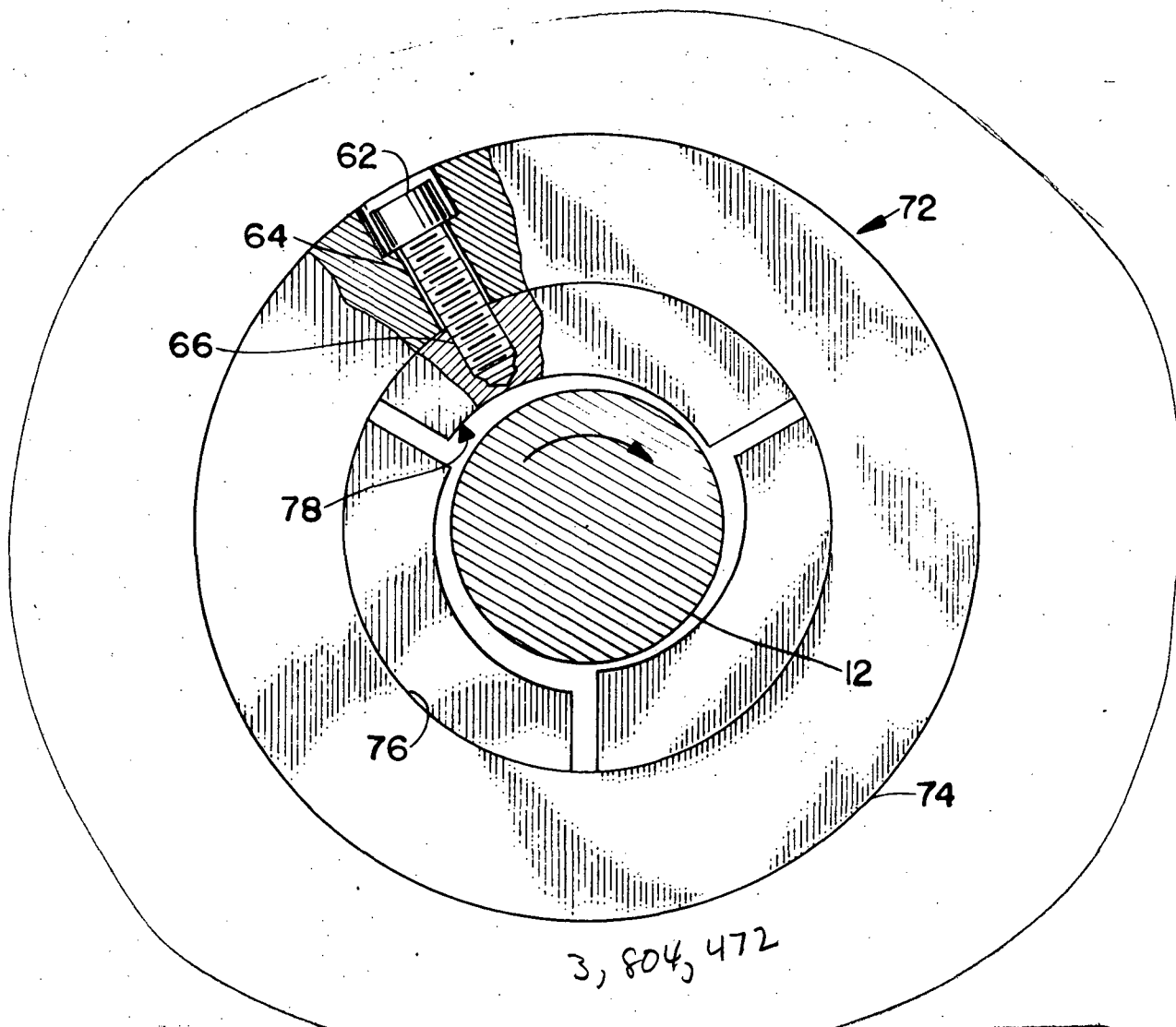
Assistant Examiner—Frank Susko

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[57] ABSTRACT

A plurality of bearing sectors are mounted in a housing. Each sector functions as a lobed area in the bearing to obtain the required lubricant film geometry.

2 Claims, 10 Drawing Figures



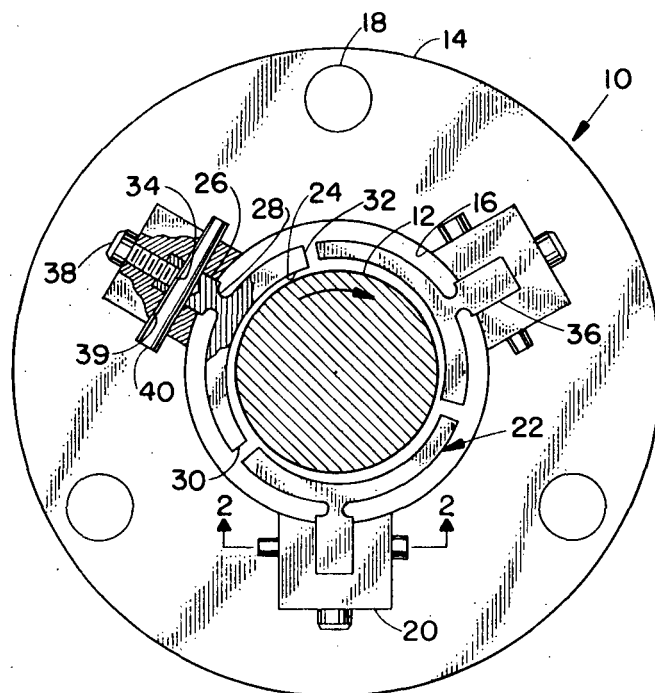


FIG. 1

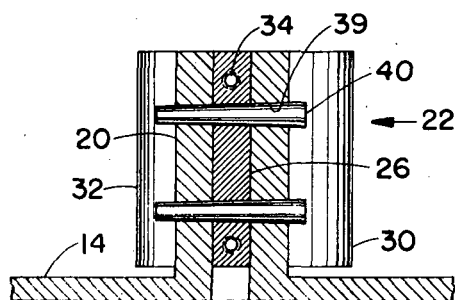


FIG. 2

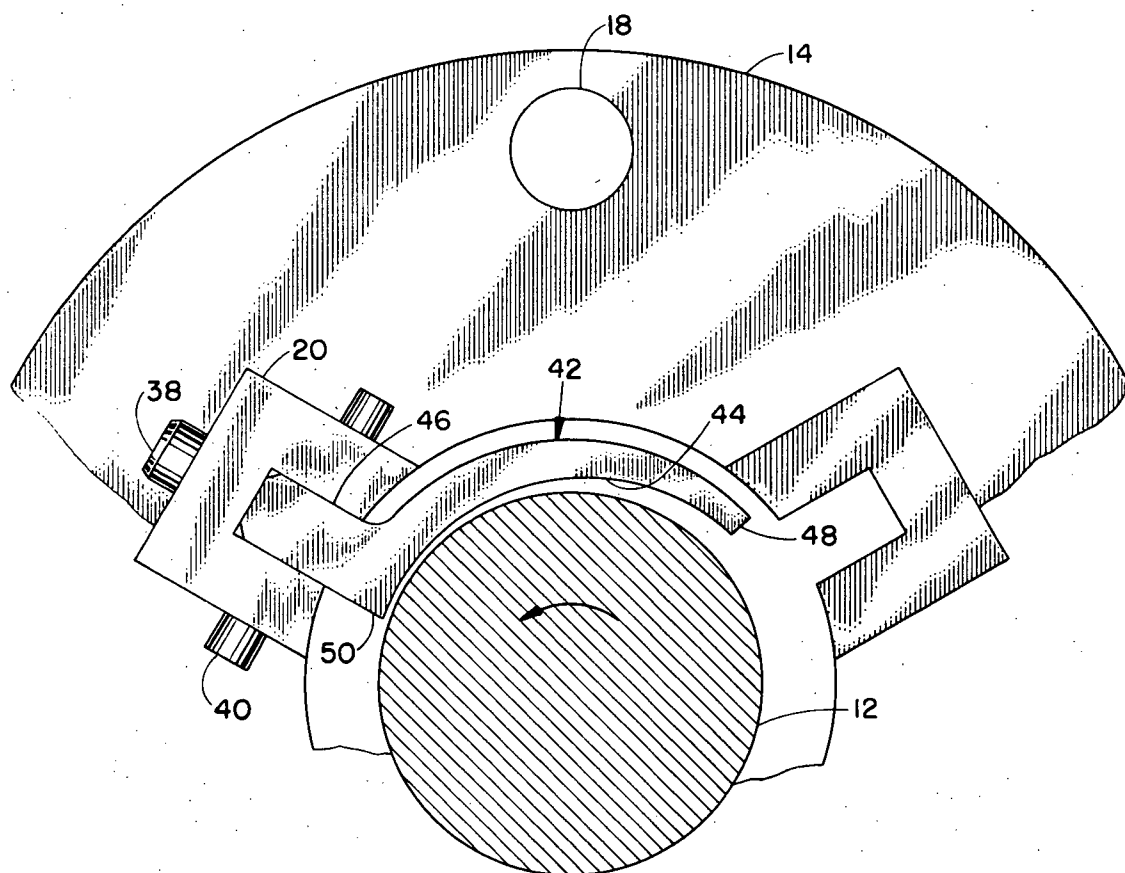


FIG. 3

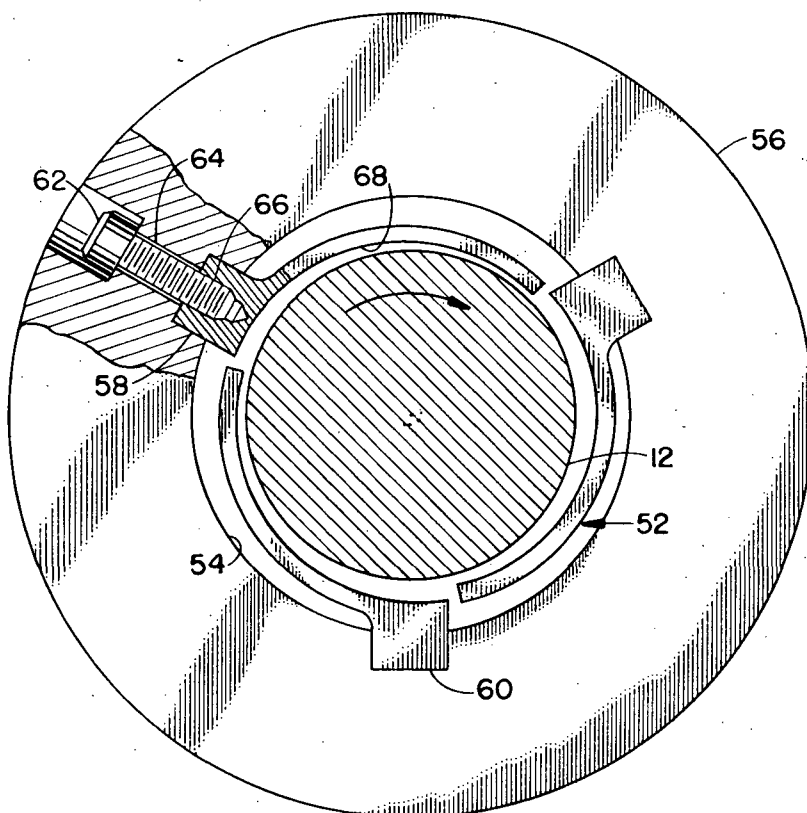


FIG. 4

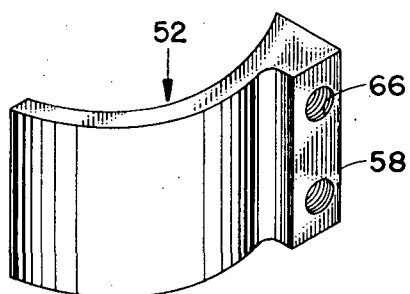


FIG. 5

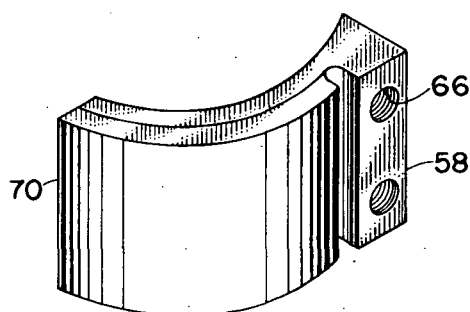


FIG. 6

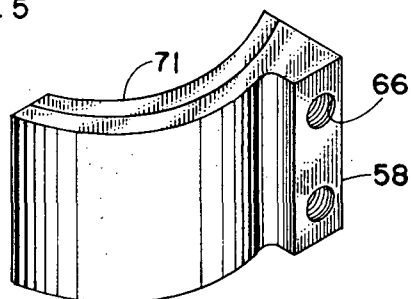


FIG. 7

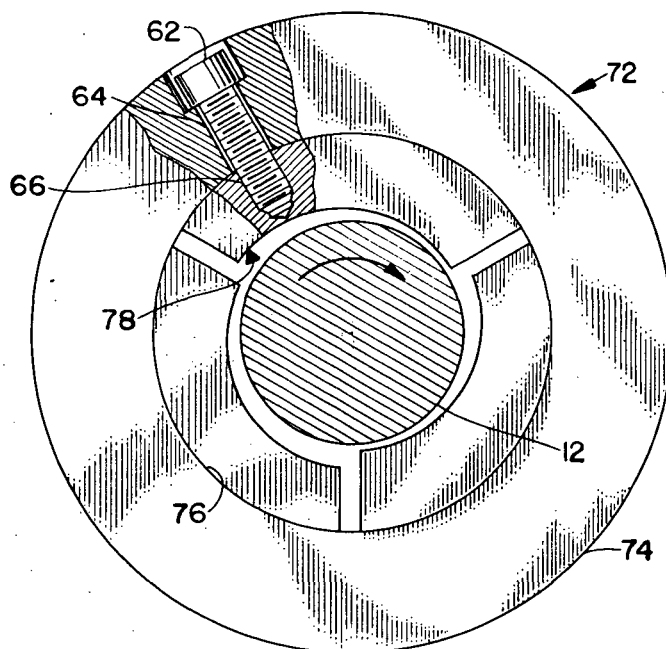


FIG. 8

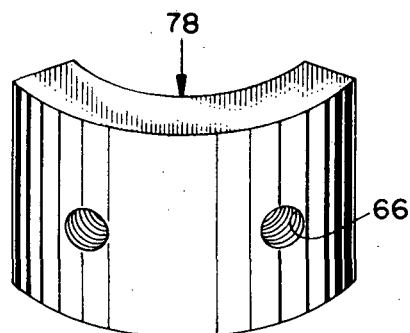


FIG. 9

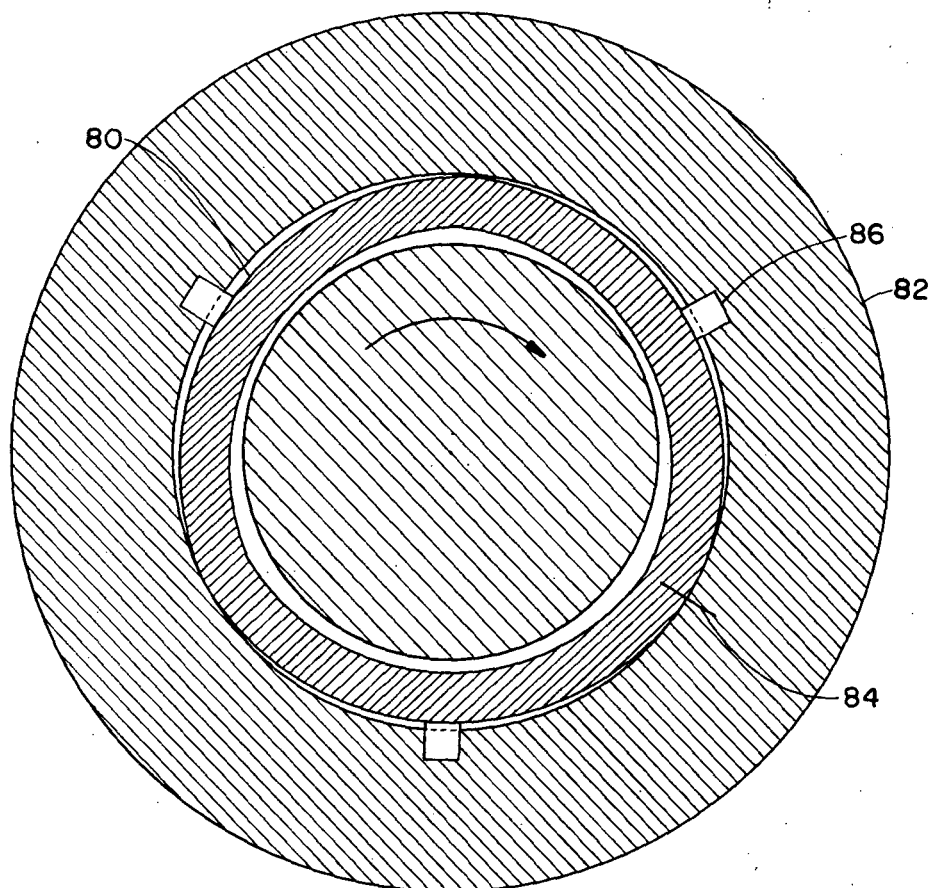


FIG. 10

JOURNAL BEARINGS

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention is concerned with the instability of zero or lightly loaded shafts when they rotate at high speeds in bearings in low viscosity lubricants. This instability refers to a self-excited fractional-frequency whirl or tendency of the shaft center to orbit the bearing center at an angular velocity about half that of the shaft around its own center.

This tendency of lightly loaded rotors running at high speeds to orbit or whirl about the bearing center is caused by a film force component, acting at right angles to the line of centers of the journal and bearing, which predominates under light or zero load conditions. This self-excited instability produces an outward spiraling of the rotor in the direction of shaft rotation when the speed is increased. Destructive seizure may result if the rotor contacts the bearing.

The successful operation of a power generation system for space vehicles employing liquid metals as the working fluid depends upon the ability of a journal bearing to inhibit this instability. Tilting pad bearings have been proposed for such applications because these bearings are exceptionally stable. However, tilting pad bearings are complex in that they contain several parts and may be subject to pivot surface damage.

SUMMARY OF THE INVENTION

These problems have been overcome by utilizing bearings constructed in accordance with the present invention. Each bearing is of fixed geometry and utilizes a plurality of sectors to provide lobed areas which function as a pump when the rotor turns. The resulting pressure distribution is similar to that obtained in a hydrostatic gas bearing.

The geometry of the lubricant film depends on the configuration of the sectors. The film geometry may be converging, diverging, or a combination thereof.

It is, therefore, an object of the present invention to provide an improved journal bearing which may be constructed without expensive and complicated machining procedures.

A further object of the invention is to provide an improved journal bearing having removable lobed sectors which are easily replaced in case of damage.

Another object of the invention is to provide an inexpensive bearing having improved stability and simplified damping.

These and other objects of the invention will be apparent from the specification which follows and from the drawings wherein like numerals are used throughout to identify like parts.

DESCRIPTION OF THE DRAWINGS

Referring now to the drawings:

FIG. 1 is a plan view with parts in section of a bearing constructed in accordance with the present invention;

FIG. 2 is a section view taken along the line FIG. 2-2 in FIG. 1;

FIG. 3 is an alternate embodiment of the bearing shown in FIG. 1;

FIG. 4 is an alternate embodiment of the bearing shown in FIG. 3;

FIG. 5 is a perspective view of a sector of the bearing shown in FIG. 4;

FIG. 6 is an alternate embodiment of the sector shown in FIG. 5;

FIG. 7 is another alternate embodiment of the sector shown in FIG. 5;

FIG. 8 is a plan view with parts in section of still another embodiment of a bearing;

FIG. 9 is a perspective view of a sector of the bearing shown in FIG. 8; and

FIG. 10 is a cross section view of still another embodiment of a bearing.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, there is shown in FIG. 1 a bearing 10 constructed in accordance with the present invention which produces a converging-diverging film geometry. A lightly loaded shaft 12 rotates at high speed in the bearing 10 in a clockwise direction as indicated by the arrow. This shaft may operate stably at speeds as high as 9,000 rpm under a very light or zero load in low viscosity fluids such as water.

The bearing 10 comprises a housing in the form of a circular plate 14 having a bore 16 extending along the bearing axis for receiving the shaft 12. Suitable holes 18 are provided in the plate 14 for rigidly mounting the bearing and maintaining it in a stationary position as the shaft 12 rotates.

A plurality of rigid posts 20 extend outward from the plate 14 along the shaft 12 as shown in FIGS. 1 and 2. These posts are equally spaced about the bore 16.

According to the present invention a plurality of sectors 22 are mounted on the posts 20 as shown in FIGS. 1 and 2. Each sector 22 comprises a pad 24 flexibly mounted to a base 26 with a neck 28 having reduced thickness. In this manner the neck 28 forms a pivot for the pad 24 between its leading edge 30 and trailing edge 32.

The minimum radial clearance between the pad 24 and the shaft 12 is at the neck 28. Both the neck and the minimum radial clearance are located at a point approximately sixty percent of the sector arc length measured from the leading edge 30 of each sector.

All of the sectors 22 for each bearing 10 are preferably fabricated from a common cylinder of bearing material. The inside of this cylinder is rough bored to an inside diameter which approximates the outside diameter of the shaft 12. A plurality of holes 34 are drilled and tapped at the location of each mounting base 26.

The outside surface of the cylinder is machined to the contour of the attached sectors 22. The neck 28 of each sector 22 is machined to the desired thickness. This thickness is dependent upon the amount of flexibility desired. The cylinder is then cut into the desired number of pieces to make the sectors 22 for the bearing 10.

The base portion 26 of one sector 22 is inserted into a slot 36 in a post 20. Mounting screws 38 extend through the post 20 and are tightened into the threaded holes 34. Taper pin holes 39 are machined, after assem-

bly, through the post 20 and base portion 26. Taper pins 40 are then inserted through the post 20 and the base 26 to rigidly secure the sector 22 in the bearing 10.

The surface of the pad 24 is then ground to a radius greater than that of the shaft 12 with its center offset a predetermined amount in a direction away from the neck 28 of the sector 22. Minimum radial clearance at the neck 28 is achieved by maintaining the axis of the grinding wheel on a line passing through the center of the bearing 10 and the base 26. After each sector 22 has been individually finish ground all the sectors are rigidly mounted in the bearing housing.

DESCRIPTION OF ALTERNATE EMBODIMENTS

Referring now to FIG. 3 there is shown an alternate embodiment of the invention which is used to produce a wholly converging film geometry. This embodiment utilizes a bearing sector 42 comprising a pad 44 rigidly mounted on a base 46. The sectors 42 are produced in a manner similar to that used to machine the sectors 22 shown in FIGS. 1 and 2.

The sectors 42 are mounted in the posts 20 in the same manner as the sectors 22. The base 46 is formed on the extreme end of the sector 42. No neck of reduced thickness is used in this embodiment. The amount of sector flexibility is dependent on the wall thickness of the sector 42. The rigid portion of the sector 42 is located at the trailing edge 50 of the sector. The minimum radial clearance is at the approximate trailing edge 50 which is the most rigid portion of the sector 42. The maximum radial clearance is at the leading edge 48 which is the most flexible portion of the sector 42.

The bearing shown in FIG. 4 is similar to the one shown in FIG. 3 with the exception that the shaft 12 rotates in the opposite direction. In this manner the most rigid part of the sector is at the leading edge and the most flexible portion is at the trailing edge.

In this embodiment a plurality of sectors 52 are mounted in a bore 54 of a cylindrical bearing housing 56. One of the sectors 52 is shown in greater detail in FIG. 5.

Each sector has a rigid base 58 as shown in FIGS. 4 to 7 inclusive. The base 58 is mounted in a suitable slot 60 in the housing 56 as shown in FIG. 4. Each sector 52 is held in place in its slot 60 by a pair of screws 62 which extend through holes 64 in the housing 56. The screws 62 are received in tapped holes 66 in each base 58. When the screws 62 are tightened the base 58 of each sector 52 is rigidly mounted in the slot 60.

In this embodiment a pad 68 extends from the base 58 in the direction of rotation of the shaft 12. Each sector 52 has a thin wall and forms a cantilevered spring which converges in the direction of shaft rotation towards the shaft 12. The minimum radial clearance is at the trailing edge of each pad 68. The pads 68 form a wholly converging film geometry.

Referring to the embodiment shown in FIG. 6 the spring action of the cantilevered pad 68 is damped. This is achieved by bonding a layer 70 of suitable damping material to the back surface of each sector 52. A layer of rubber has been satisfactory for this purpose.

A temperature compensating bearing is shown in FIG. 7. In this embodiment the sector 52 is a bimetal. One metal layer 71 is bonded to the sector 52. As the ambient temperature changes, the bi-metallic sector

moves away from or towards the shaft 12 depending on the coefficient of expansion of the two bonded metals.

The inside radius of each bearing sector 52 is rough machined before assembly. The sectors 52 are then assembled individually in the bearing housing 56. The sectors are finish ground individually on the inside diameter by off-setting the center of the bearing housing 56 with that of the grinding wheel a predetermined amount that will result in a particular internal bearing geometry desired. After all the sectors 52 have been individually ground these sectors are assembled into the axial slots 60.

Referring now to FIG. 8 there is shown a three-lobed bearing 72. This embodiment is particularly useful where it is necessary to replace portions during its life. The bearing 72 is similar to the embodiment shown in FIG. 4 in that a shaft 12 rotates in a housing 74. A bore 76 extends through the housing, and the shaft 12 rotates in this bore. A plurality of rigid sectors 78 are mounted in the bore 76 by screws 62 extending through holes 64.

The bearing 72 is made by first drilling the housing 74 with equally spaced clearance holes 64 for receiving the hold down screws 62. These screws pass through the housing 74 into the sectors 78 and draw them rigidly against the inside diameter 76.

To fabricate the bearing sectors, a cylinder of bearing material is machined with the outside diameter identical to the inside diameter of the housing bore 76. The cylinder has a rough inside diameter somewhat less than the desired finished inside diameter of the sectors 78. Blind holes 66 are drilled and tapped on the outside of the cylinder of bearing material. This cylinder is then cut into equal pieces. Each of these pieces forms a sector 78 of the bearing.

Each of these resulting sectors is individually assembled into the bearing housing 74 and bolted tightly against the housing inside diameter by the two hold down screws 62. The center of a grinding tool is then offset from the center of the housing bore 76 to produce the desired radius and tilt of the sector 78. When the first sector is finish machined it is removed and the next sector is assembled and machined using the same procedure.

This embodiment is particularly useful where it is necessary to replace the sectors throughout the life of the bearing. When the original three sectors have been fabricated any number of sectors can be machined to identical dimensions and stored for replacement parts. When all the sectors have been completely machined three of them are bolted into the housing. A circumferential surface trace can be made of the assembled bearing to insure each has the desired profile.

If a bearing failure occurs it is only a matter of removing the hold down screws 62 that hold the sectors 78 to the bore 76 of the housing 74. The damaged sector is removed and replaced with one of the extra sectors. Thus removal of the bearing housing and reboring the inside diameter is not necessary for replacing these parts.

In the embodiment shown in FIG. 10 no internal offset machining is required. In this embodiment a cylinder 80 of a bearing material is assembled into a bearing housing 82 without shimming by subcooling the cylinder, or heating the housing. The cylinder 80 is machined in place to a predetermined inside diameter. An

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identification mark **84** is imprinted on one surface of the cylinder **80** and the housing **82**.

The cylinder **80** is removed from the housing **82** by subcooling or heating the assembly. Suitable shims **86** are placed around the inside diameter of the housing **82** in an equally spaced manner. These shims are secured to the top of the housing **82** by tack welding or taping to prevent dislocation during assembly. The thickness of each shim **86** is dependent in part upon the lobe height desired.

The cylinder **80** is again assembled in the shimmed housing **82** by subcooling the cylinder or heating the housing **82**. During the assembly the identification mark **84** is aligned. When the cylinder **80** and the housing **82** have reached equilibrium conditions of temperature, an inside diameter trace can be made of the resultant contour. This will identify accurately the size of the lobing which has been obtained. The amount of lobing will depend on the thickness of the shims **86** as well as the physical properties of the bearing housing **82**, the shims **86**, and the bearing material **80**.

While various embodiments of the invention have been shown and described it will be appreciated that other structural modifications may be made without departing from the spirit of the invention or the scope of the subjoined claims.

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What is claimed is:

1. In combination with a lightly loaded shaft rotating at high speed having a film of lubricants thereon, an improved bearing comprising

a housing having a bore extending therethrough for receiving such shaft,

a plurality of sectors in said bore positioned around said shaft, each of said sectors having a surface facing said shaft forming a lobed area in said bearing for shaping the geometry of said film of lubricants, said sectors being rigid whereby the spacing between said surface and said shaft is constant, said surface of each of said sectors being angularly disposed relative to said shaft with the minimum radial clearance between said surface and said shaft being at the trailing edge of each of said sectors and the maximum radial clearance being at the leading edge of each of said sectors to produce a converging film geometry, and

threaded means passing through said housing into each of said sectors for drawing the same rigidly against the bore of said housing whereby individual sections can be selectively replaced.

2. Apparatus as claimed in claim 1 including at least three identical sectors in the bore of housing.

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